DATA SCIENCE IS THE CRITICAL BUILDING BLOCK FOR MULTI-FIELD TECHNOLOGICAL ADVANCES

Artificial Intelligence has rapidly moved from being a buzz word just a few years back to now being the epicenter of technological revolution in almost all of industry sectors. Combined with Machine Learning, Artificial Intelligence has changed from being a differentiator to a core competency in multiple fields.

The advent and progress of AI has captured the attention of almost all opinion leaders in the world of technology, with the opinions ranging from buoyant patronage to dooms-day predictions.

> **"**
> *Some people call this artificial intelligence, but the reality is this technology will enhance us, So instead of artificial intelligence, I think we'll augment our intelligence.*
>
> *– GINNI ROMETTY*
> **"**

> **"**
> *Robots are not going to replace humans, they are going to make their jobs much more humane. Difficult, demeaning, demanding, dangerous, dull – these are the jobs robots will be taking.*
>
> *– SABINE HAUERT*
> **"**

> **"**
> *If we do it right, we might be able to evolve a form of work that taps into our uniquely human capabilities and restores our humanity. The ultimate paradox is that this technology may become a powerful catalyst that we need to reclaim our humanity.*
>
> *– JOHN HAGEL*
> **"**

> **"**
> *It seems probable that once the machine thinking method had started, it would not take long to outstrip our feeble powers... They would be able to converse with each other to sharpen their wits. At some stage, therefore, we should have to expect the machines to take control.*
>
> *– ALAN TURING*
> **"**

> **"**
> *The pace of progress in artificial intelligence (I'm not referring to narrow AI) is incredibly fast. Unless you have direct exposure to groups like Deepmind, you have no idea how fast – it is growing at a pace close to exponential. The risk of something seriously dangerous happening is in the five-year timeframe. 10 years at most.*
>
> *– ELON MUSK*
> *wrote in a comment on Edge.orgt*
> **"**

> **"**
> *The development of full artificial intelligence could spell the end of the human race.... It would take off on its own, and re-design itself at an ever-increasing rate. Humans, who are limited by slow biological evolution, couldn't compete, and would be superseded.*
>
> *– STEPHEN HAWKING told the BBC*
> **"**

While only time will tell if the possible perils of Artificial Intelligence and the learning and reasoning by machines without the intervention of humans will be mitigated by our advancement in understanding how best to deploy the technology, the tremendous potential that it has to change the very nature of our industries and societies is undeniable. At Bosch, we have been early adopters and pioneers of futuristic technology and we thus continue to deploy thoroughly researched and safe solutions that employ AI and ML at the core of the performance of our digital solutions since the last few years.

DIVERSE APPLICATIONS OF AI AND ML AT BOSCH

The greatest strength of AI and ML solutions is the diversity of the applications that can be immediately enhanced with the distinct advantages that the technology provides. While we have found numerous use-cases across all the sectors that we operate in, below are 3 important industries where our solutions have already disrupted the fundamentals of the way that the industry operates.

APPLICATION OF AI

HEALTHCARE

Assisted Diagnosis

Patient Summary

Drug Discovery

AGRICULTURE

Weather Forecasting

Soil Health Monitoring

Crop Health Monitoring

AUTOMOTIVEAUTOMOTIVE

Predictive Maintenance

Self-Driving Vehicles

Driver Behavior Monitoring

AI IN THE CURRENTLY ON-FIRE FIELD OF HEALTHCARE

In the field of healthcare, AI assists both care-seekers and care-providers in increasing accuracy and efficiency of the diagnosis and also in the convenience of the service delivery.

PREVENTIVE DIAGNOSTICS

AI helps in recognizing patients' symptoms and then guide them to the right remedy based on intelligent and accurate diagnosis. It can predict and diagnose diseases at a faster rate and earlier than most medical professionals.

SMART DECISIONS

Learning patterns in patients' history using data from multiple reports such as radiology images, blood tests, EKGs, genomics, patient medical history, etc., AI assists the medical care provider in making faster and highly informed decisions.

ACCELERATING DRUG DISCOVERIES

AI can be deployed across the entire chain of drug discovery and trials and greatly enhances the speed, efficiency and scaling in drug trials, drug discoveries and to discover new uses of existing drugs.

SMART OPERATIONS

AI is being used in managing the everyday operations by healthcare providers and is helping digitize activities such as staffing, medical records arranging transferring, etc.

AI IN THE ALL-IMPORTANT AGRICULTURE SECTOR

WEATHER FORECASTS

Weather forecasting is critical to agriculture planning and AI helps in increasing the accuracy of weather forecasts thereby saving enormous amounts of capital and crops that get wasted due to delays and errors in weather forecasting.

SOIL HEALTH MONITORING

AI helps farmers keep the health of their soil in constant check in order to maximize the utilization of the soil while also ensuring that farmers can take up the most sustainable way of using their soil for various crops.

CROP MONITORING

Maximizing the crop yield is a critical parameter in creating profitable agricultural operations and AI can help in increasing crop yields by monitoring the health of crops throughout the growing season in order to be able to take preventive and reactive measures in case of discrepancies. AI also helps in identifying the produce quality to ease crop valuation activities.

SMART FARM OPERATIONS

Deploying AI based solutions in important farm operations such as seed sowing, smart watering, fertilizing and crop harvesting substantially increases the efficiency and effectiveness of agricultural operations management.

AI REVOLUTIONIZING THE MOBILITY INDUSTRY

THE NEAR-FUTURE OF DRIVING

AI is the base of the transformation of driving and is ushering in the era of self-driving cars. The current generation of mobility features such as smart cruise control, intelligent driver assists, automated safety are all also built using AI capabilities.

NEW WAY OF NAVIGATION

Traditional navigation techniques are almost dead now its AI creating the abilities to provide real-time GPS, shortest route suggestions, effective fleet management etc. thereby saving time, money and fuel.

VEHICLE MANAGEMENT

The penetration of AI in the vehicle starts from manufacturing robots to create the vehicle and extends to the full lifecycle providing end-user and industry benefits such as predictive maintenance, warranty claims analysis, driver behavior monitoring etc.

HOW WE DROVE SUCCESS WITH AI SOLUTIONS

Bosch continues to be one of the leading contributors in the field of AI by implementing state-of-the-art solutions to most of the inconceivable challenges that various industries are facing in today's world. Our AI based digital solutions in Healthcare, Agriculture and Mobility sectors utilize various new age technologies such as Computer vision, NLP etc. Here are some interesting success stories of how our AI algorithms have been driving amazing Bosch products across industries.
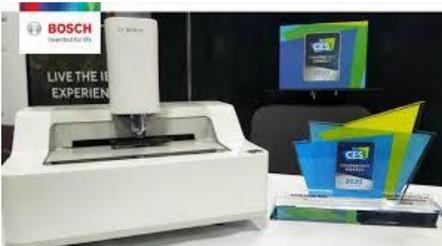
DOCUMENT SEARCH ENGINE

THE PROBLEM

The service engineers at a global automotive OEM were struggling with the huge burden of matching customer complaints with identified defects in their products. The data available on the complaints and the identified defects were both in the form of text collected from the field. They had to manually search through thousands of defect documents to match hundreds of complaints every week in order to match them with each other.

One of the major challenges in the problem was that the defect documents as well as the customer complaints had a mix of languages, with Japanese and English being the most frequent languages that had been used. Another difficulty was that the text data had been written by the OEM's distribution partners and had been written with the usage of short forms for words and did not follow grammatical guidelines of the languages.

TRAINING

```
[List of Documents] → [Text Processing] → [List of processed Documents] →   MODEL
                                                                      [Build vocabulary of words] → [Assign numeric vectors to each word]   → [Word vectors]
```

TESTING

```
[New Document] → [Text Processing] → [Model] → [Vectorized Document] → <Similarity> → [Output top n similar results]
                                                                            ↑
                                                                    [Vectorized Document]
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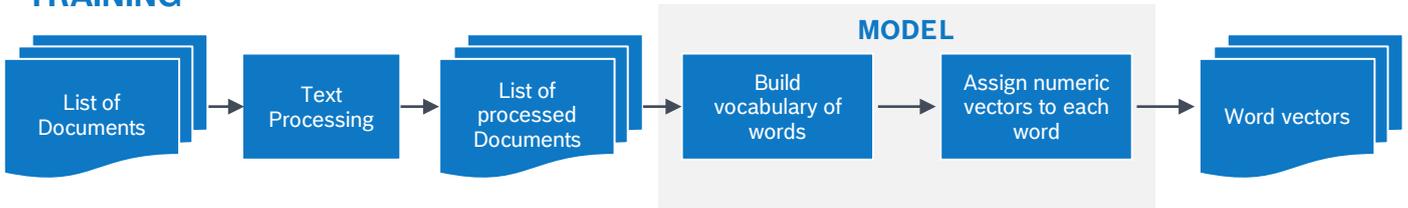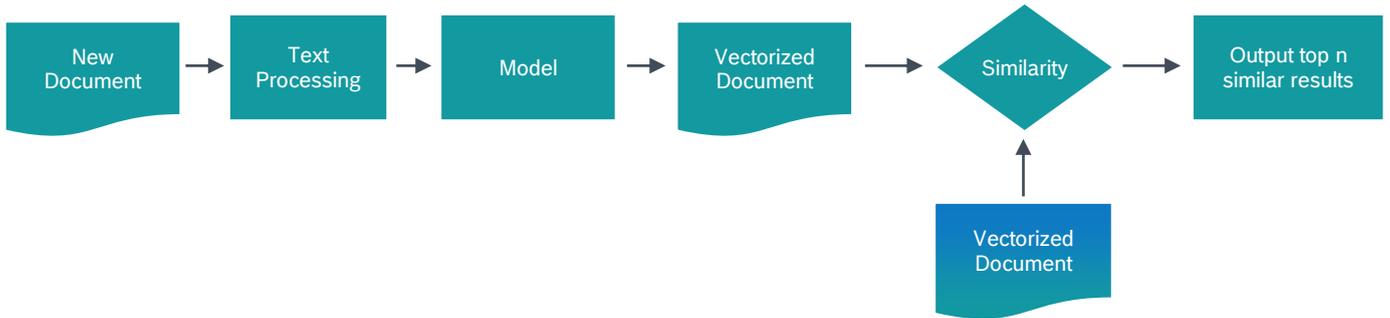
The architecture above gives an overview of how the search engine was built in the training and testing phases. The solution is based on Natural Language Processing (NLP) tools and models, and contains text processing functions which translate and preprocess the mixed language texts. Then, stemmers and tokenizers are used to convert the documents into words which are then passed through ML models that generate word vectors. These word vectors are stored in the database to be used during the text matching analysis.
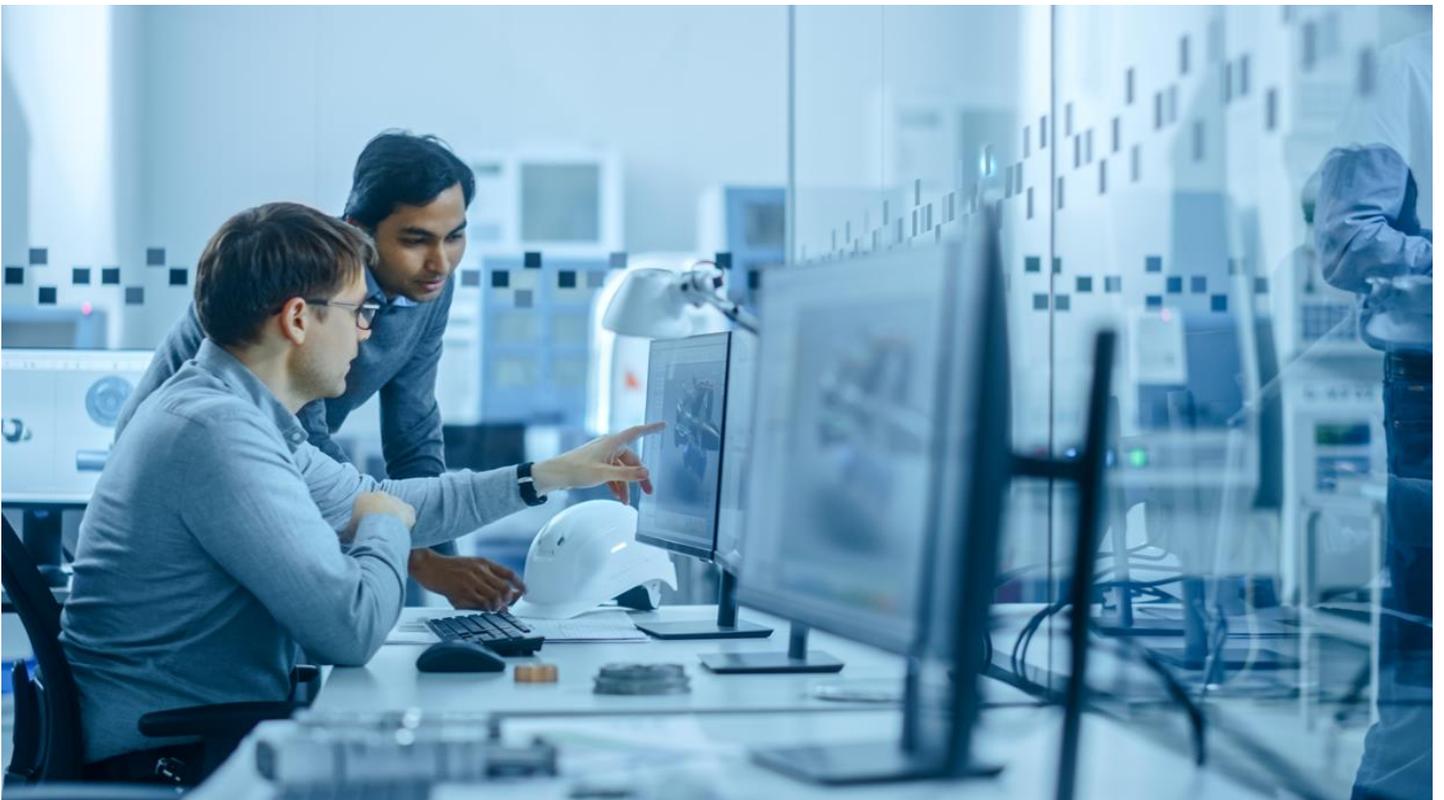
FARM ACTIVITY MONITOR

THE PROBLEM

Farmers in Norway only get 5 months of sunshine from April to August and have to utilize this growing season to maximize their farm produce. Thus, they toil for long hours during this short period. To aid them, a Norwegian technology company, required a digital solution to help farmers optimize their agricultural operations and thus maximize results.

Average Daylight hours / Average sunshine Oslo, Norway

Daylight hours / Average sunshine Oslo, Norway

■ Daylight Hours ■ Sunshine Hours

Month	Daylight Hours	Sunshine Hours
JAN	6.9h	1.3h
FEB	9.2h	2.7h
MAR	11.9h	4.1h
APR	14.6h	5.9h
MAY	17.2h	7.1h
JUN	18.7h	8.3h
JUL	17.9h	7.9h
AUG	15.5h	7h
SEP	12.8h	4.8h
OCT	10.1h	2.8h
NOV	7.6h	1.7h
DEC	6.1h	1.1h
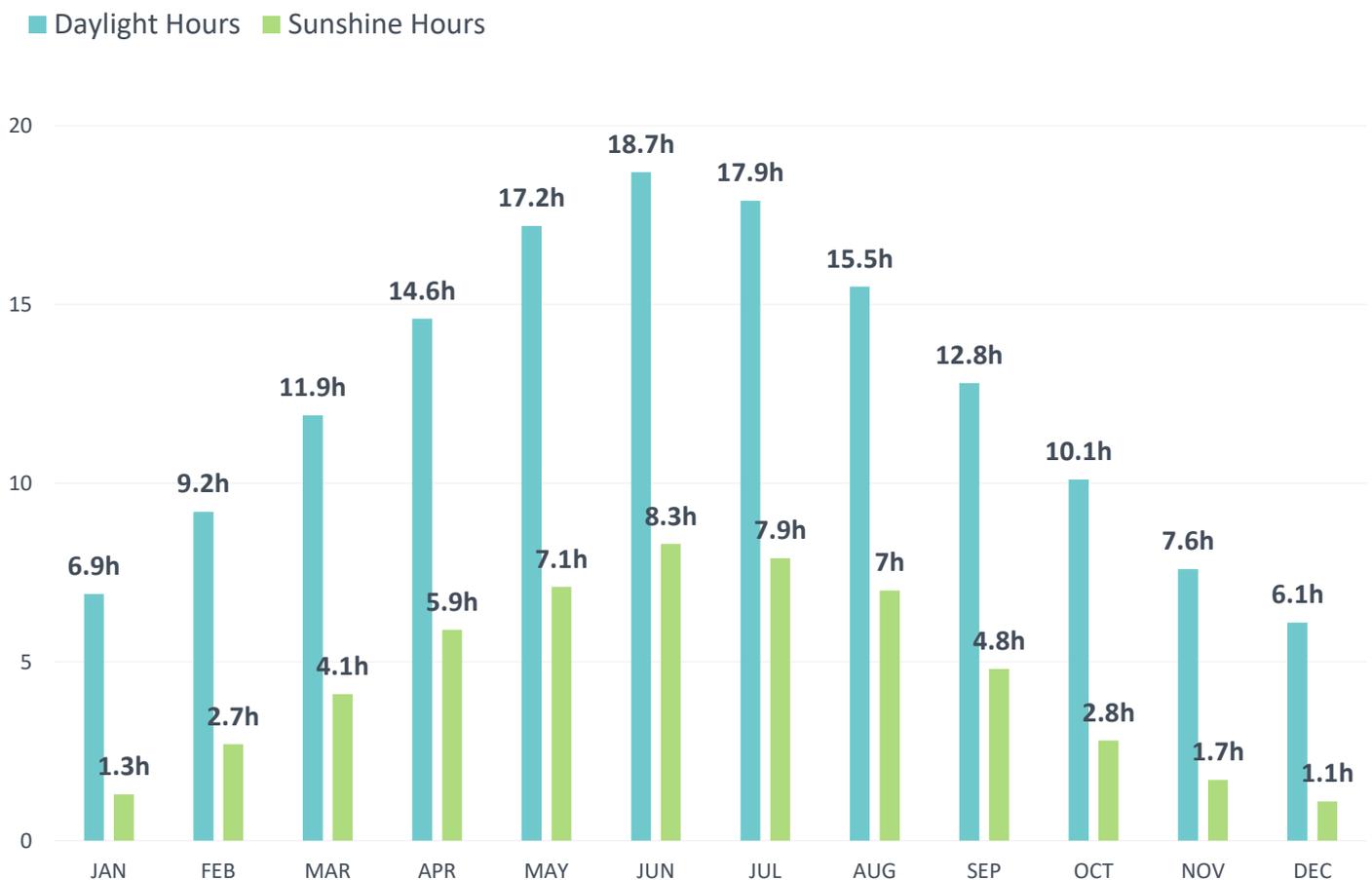
THE SOLUTION

Bosch devised a sound-based AI solution to track farming activities in real-time and help monitor the utilization of farmers' tractors, tillers and other machinery components using just their mobile phones. The AI solution is built on sound based analytics to identify and monitor the farm equipment. Our solution first extracts useful audio features and then removes noise from the recording such as human speech, music and miscellaneous background noises using an ensemble classification model. One-class classification models are then used to perform novelty detection to verify if the recording belongs to known or unknown farming activities. Finally, the solution performs multi-class classification to differentiate and recognize the distinct sound signatures of more than 20 different farming activities and thereby helps measure utilization of these machines. The solution is also equipped with intelligence that helps geographically identify farm boundaries in which it is deployed to ensure complete accuracy in the tracking of operations.

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TRAINING

| List of audio files | → | Noise removal / Audio processing | → | List of processed Audio files | → | Extract features from audio files | → | Train the ML/DL classifier |

TESTING

| New Audio file | → | Noise removal / Audio processing | → | Predicted model | → | Output the predicted label |
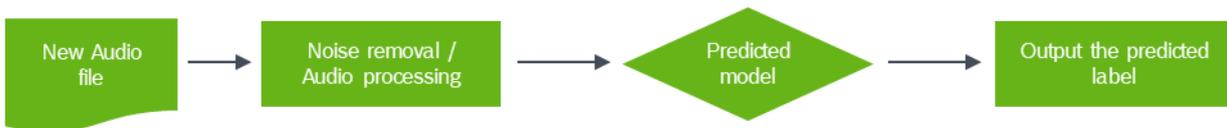
The solution architecture as depicted above comprises of a mobile application built with a completely customized AI algorithm. The farmer starts the task through a switch on the app and the audio files are then read periodically from the mobile device and stored in S3 until the end of the task. Once the task is finished, the farmer stops the task using the switch on the app again. The algorithm analyses the collected audio samples and generates task related reports while also sending a copy of the reports to the local authorities for reference in a matter of seconds after the task is switched off by the farmer. The solution is also capable of rapidly retraining the algorithm models based on the feed-back collected from the farmers and is memory and time-efficient since the solution architecture is designed for batch-wise prediction.

Farmers with our solution can now easily access extensive reports on their overall productivity and view various parameters of agricultural operations such as ploughing, sowing, tilling, harvesting etc. The solution also helped farmers earn carbon-subsidies from their local governments through the automated integration of the reporting.

CELL AND TISSUE DIAGNOSTICS

THE PROBLEM

A global leader in healthcare wanted to integrate digital solutions into pathology and use the advances in AI for histological studies. The digital solution needed to be appropriate to be applied across the diverse range of use cases in cell phenotyping such as identify, classify and count the different types of cell and region-based segmentation of multiple cell-types.

THE SOLUTION
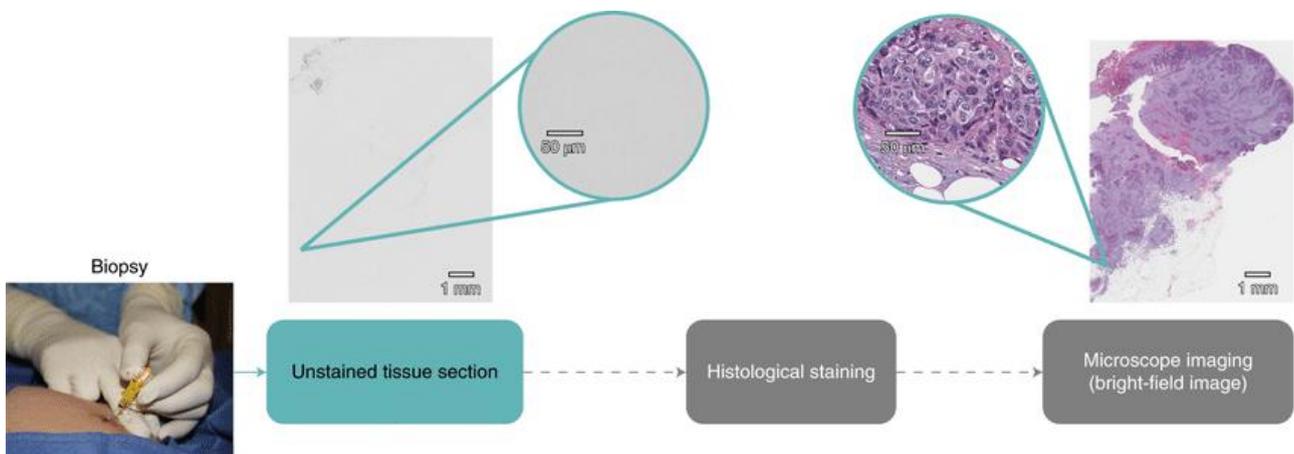
With the objective of the solution to be applicable in cell phenotyping, Bosch designed solution based on Deep learning and Digital Image processing. The model of choice is Deep Neural Network (DNN) which helped us in segmentation and cell phenotyping. In addition, we have integrated different backbones for better feature extraction. In addition, to neutralize the images coming from different sources we have used multiple image pre-processing steps.

TRAINING

TESTING
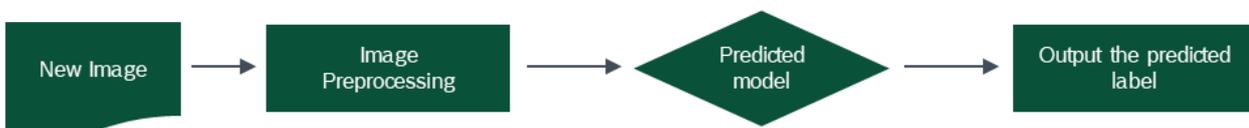
CONCLUSION

At Bosch, we believe that Text, Sound, and Image Analytics will be the core of the world's complete movement into the era of Artificial Intelligence. Their application is diverse and is rapidly penetrating into every domain of business. As the utilization of AI grows, so will the demand for huge neural networks to deploy AI based solutions. The computing power for these neural network also continues to grow as models become increasingly accurate. However, with the rapidly progressing development to make these models light enough to be used in handheld devices like our smart phones, Artificial Intelligence and Machine Learning will engulf most of our everyday functions and enhance human achievements to new unimagined levels.

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